Influence of Plate Size and Design upon Healing of Ulna-Shortening Osteotomies

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Abstract

Purpose Ulna-shortening osteotomy is one of the most established and most frequent operations in hand surgery. However, bone union is not always achieved and the use of plates implies potential risks and problems. The traditional points of criticism are the duration of bone healing, the incidence of nonunion, and the necessity of hardware removal due to the soft tissue irritation by the plate or the screws. These shortcomings have been addressed by an increasing standardization of the procedure and finally specific instruments and implants. The aim of this retrospective study was to compare a new LCP (locking compression plate) Ulna Osteotomy System 2.7 mm (Synthes, Paoli, PA) with the former 3.5-mm LCDCP (limited-contact dynamic compression plate) (Synthes) regarding consolidation, complications, and rate of plate removal.

Methods To investigate the effect of an implant and technique specifically designed for this purpose, we have compared the course of healing and the result in 72 patients who have undergone ulnar shortening osteotomy using general instruments and applying a standard osteosynthesis plate (Synthes, 3.5-mm LCDCP) to a consecutive cohort of 40 patients who had ulnar shortening using the new dedicated ulna-shortening osteotomy system plate (Synthes, 2.7-mm LCP). Clinical and radiologic evaluation was performed 8 weeks, 3 months, 6 months, and 1 year postoperatively in all patients.

Results The latter displayed shorter bone healing time, suggesting an advantage of an oblique osteotomy. There was no significant difference in rate of plate removal. Ultimate complication and consolidation rate was not different.

Conclusion Using the new LCP 2.7 implant, time to consolidation was shorter and oblique osteotomies healed faster than transverse ones. However, in spite of the smaller plate, screws, and tapered design, the plate did not cause less local problems and failed to decrease the necessity of plate removal. Furthermore, the cost of the implant is higher than the LCDPC 3.5.

Type of Study Retrospective comparative study.

Therapeutic evidence Level III

Keywords
- ulna shortening
- osteotomy
- osteosynthesis
- ulnocarpal impaction

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Different methods of ulnar shortening are used in the treatment of ulnocarpal impaction.[1,2] Among these shortenings, osteotomy of the ulnar shaft with plate fixation is an established method. Complications of plate fixation include loosening, loss of reduction, nonunion, and painful hardware with need for implant removal. To improve on these shortcomings, a new plating system was introduced in 2010 including a shorter LCP 2.7 (Synthes) with rounded edges, tapered ends, and specific drill guides paired to parallel saw blades. The aim of this retrospective study was to compare this new LCP 2.7 mm with the former 3.5-mm LCDCP (Synthes) regarding consolidation, complications, and rate of plate removal. The hypothesis was that with the use of the new LCP 2.7 mm, less hardware removals would be necessary than with the previous 3.5 LCDCP and the healing of the osteotomies would not present more problems in terms of percentage, time, and complications.

Methods

A total of 137 patients were treated with ulna-shortening osteotomies in the period from March 2003 to August 2012 by two surgeons at our institution. Institutional review board approval was not necessary. In this time, two different plates were used.

Between March 2003 and May 2010, 73 ulna-shortening osteotomies were performed on 72 patients using a six-hole 3.5-mm LCDCP (limited-contact dynamic compression plate) by Synthes (►**Fig. 1**). These 72 patients represent group 1. All 73 osteotomies were transverse.

After its introduction, the LCP (locking compression plate) Ulna Osteotomy System 2.7 mm (Synthes) was used beginning in July 2010. This system was used in 65 patients. Of those 65 patients, 40 had a follow-up of at least 1 year and were included for evaluation in this study. These 40 patients represent group 2. The osteotomy was performed with a transverse cut in 21 patients (►**Fig. 2**) and with an oblique cut (►**Fig. 3**) in 19 patients. Osteotomy type was alternating a transverse or oblique cut.

The two patient groups did not differ in age or indication for surgery (►**Table 1**). In group 1, there were 41 male and 31 female patients (73 osteotomies), with an average age of 40 years (range, 15–70 years). In group 2, there were 20 male and 20 female patients, with an average age of 38 years (range, 15–63 years). Indications for operation were primary ulnocarpal impaction (group 1, 14; group 2, 8), traumatic triangular fibrocartilage complex rupture (48/29), secondary ulnocarpal impaction after radius fracture (18/7), and distal radioulnar joint (DRUJ) instability (32/18). The retrospectively available data did not allow for reliably assessing comorbidities or eventual smoking habits at the time of active treatment. We did not differ between smokers and nonsmokers in this retrospective study. The operative approach was identical in the two groups. We chose a palmar approach. The amount of shortening was defined on preoperative X-rays, according to operation protocol from 2 to 6.5 mm, and was not significantly different for the two groups. The plate was positioned on the palmar distal ulna diaphysis proximal to the pronator quadratus muscle.

The postoperative treatment did not differ either between the two groups. Immobilization period depended on the additive intervention and included immediate mobilization up to 8 weeks immobilization. There were 36 patients with short arm casts and 37 with long arm casts in group 1. In group 2, short arm casts were used in 16 patients and long arm casts in 24 patients. The radiographic follow-up included X-rays after 8 weeks, 3 months, 6 months, and 1 year postoperatively in all patients. Radiologic and clinic evaluation

Fig. 1 X-ray of a forearm 6 weeks postoperatively using a LCDCP 3.5.

Fig. 2 X-ray of a forearm 6 weeks postoperatively using a LCP 2.7, transverse osteotomy.

Fig. 3 X-ray of a forearm 6 weeks postoperatively using a LCP 2.7, oblique osteotomy.

continued when bony union was not completed 1 year after surgery. At these follow-up dates, beginning and definitive consolidation was distinguished. Postoperative complications were evaluated in the postoperative examinations at 8 weeks, 3 months, 6 months, and 1 year. Beginning of consolidation was defined as visible callus formation or beginning of bony union, and definitive consolidation was defined as invisible previous osteotomy site. Radiological evaluation was performed by an independent orthopedic resident and a musculoskeletal-trained radiologist.

IBM SPSS Statistics for Windows, Version 22 (IBM Corp, Armonk, NY), was used for statistical analyses. Differences between the groups were analyzed with chi-squared tests, Mann–Whitney *U* test, and independent sample *t*-tests. Alpha values of <0.05 were deemed to be statistically significant.

Results

Mean time to completion of consolidation of the osteotomy in group 1 was 311 (62–664) days. In group 2, time to complete consolidation of the osteotomy was 247 days (67–538). The time to completion of consolidation in days again was significantly shorter ($p = 0.01$) using the new LCP 2.7.

Time to beginning of consolidation in group 2 using the LCP 2.7 occurred after an average of 79 days (range, 29–319 days) compared with group 1 using the LCDCP 3.5 with 88 days on average (27–174). This time was nonsignificantly shorter for the LCP 2.7 with a *p*-value of 0.28 (►**Table 2**).

In group 1, pain at the plate site occurred in 26 patients. Removal of the plate was performed in 28 cases (38.3%): in 25 cases because of pain at the plate site, and in 3 cases at the occasion of other surgeries (2 Sauvé Kapandji, 1 DRUJ-capsulolysis).

There was one major complication (defined as necessitating surgery): a compartment syndrome, necessitating fasciotomy. Minor complications (defined as ones not necessitating surgery) were complex regional pain syndrome (CRPS) (one) and plate loosening (one), both treated conservatively.

A total of 18 patients in group 2 had pain at the plate site. Removal of the plate was performed in 12 patients (30%), in two occasions in addition to other surgical procedures (arthroscopy with debridement of scaphotrapezial-trapezoid and TFC [one], and arthroscopy of the wrist and TFC shaving [one]). One major complication occurred (traumatic avulsion of the plate) necessitating surgical intervention/repeat plating. Minor complication not requiring surgery was a CRPS (seven). CRPS was diagnosed based on the Budapest criteria.

Table 1 Patients' demographic data

	Group 1 (LCDCP 3.5 mm)	Group 2 (LCP 2.7 mm)	*p*-Value
Age (y)	40 ± 1.6	38 ± 1.8	0.40
Gender			
Men	41	20	0.53
Women	32	20	
Total	73	40	
Primary ulnocarpal impaction	14	8	0.91
Secondary ulnocarpal impaction	18	7	0.38
Traumatic TFCC rupture	48	30	0.31
DRUJ instability	32	19	0.71
Short arm casts	36	16	0.42
Long arm casts	37	24	0.34

Abbreviations: DRUJ, distal radioulnar joint; LCDCP, limited-contact dynamic compression plate; LCP, locking compression plate; TFCC, triangular fibrocartilage complex.

Table 2 Results

	Group 1 (LCDCP 3.5mm)	Group 2 (LCP 2.7mm)	*p*-Value
Beginning consolidation (d)	88	79	0.28
Complete consolidation (d)	311	247	0.01
Hardware removal			
Yes	28	12	0.41
No	45	28	

Abbreviations: LCDCP, limited-contact dynamic compression plate; LCP, locking compression plate.

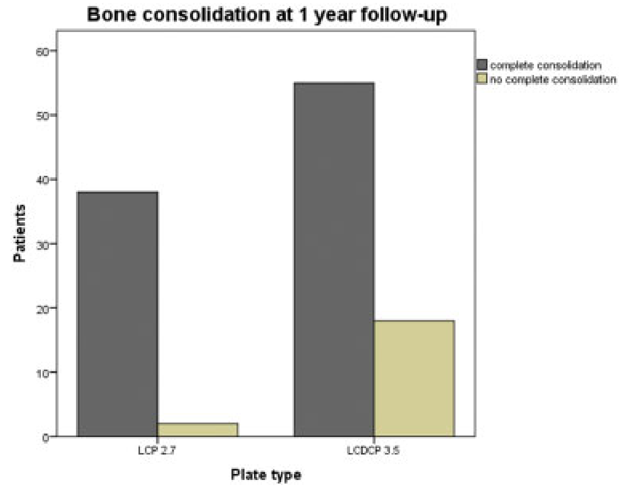

Fig. 4 Bony consolidation at 1-year follow-up.

Treatment included vitamin C for 6 months, calcitonin nasal spray for 6 weeks, and local application of dimethyl sulfoxide. With this treatment, six patients in group 2 with CRPS had a positive course with resolution of symptoms, but two patients, one in each group, had a difficult progress with chronic pain, and required rheumatologic and anesthesiologic treatment.

The rate of plate removal did not show a significant difference between the two groups ($p = 0.41$).

Interestingly, when analyzing group 2, the oblique osteotomies seemed to heal faster, but the difference was not significant ($p = 0.15$). Complete healing of the osteotomy was observed after 218 days with an oblique and after 273 days with a transverse osteotomy.

At 8 weeks postoperatively, beginning of consolidation could be found in 16 patients (40%) in the LCP group and in 18 patients (24.7%) in the LCDCP group ($p = 0.132$).

At 14 weeks postoperatively, beginning of consolidation was present in 54 patients (74%) in group 1 and in 34 patients (85%) in group 2. This difference again was not statistically significant ($p = 0.165$).

Definitive consolidation was present 6 months postoperatively in 18 patients (24.7%) while using the LCDCP and in 17 patients (42%) while using the LCP. This difference was statistically significant with a *p*-value of 0.041.

One year postoperatively, there was evidence of complete consolidation in 55 patients (75.3%) in group 1 and in 38 patients (95%) in group 2 (►**Fig. 4**), with a *p*-value of 0.006 showing a significant difference.

Discussion

This study was undertaken to document that ulnar shortening osteotomy at the shaft level can safely be performed using a dedicated plate considerably shorter and slimmer than the implants formerly recommended. There was no difference in union rates compared with the literature; the time to beginning and definitive consolidation in days was shorter using the new LCP 2.7. However, although the new plate is less bulky and appears soft tissue–friendlier, pain at the implant site and rate of hardware removal did not show significant differences between the two plates. Oblique osteotomies appeared to heal (nonsignificantly) faster than the transverse ones. Slightly more minor complications were seen in group 2, using the LCP 2.7. We attributed the higher appearance of CRPS to a higher alertness on CRPS in the last years and lower inhibition level on its treatment.

When considering the price of the implants, the 3.5-mm LCDC plate with 99 CHF was much cheaper than the new 2.7 LCP plate (411 CHF) plus the single-user double saw blade (231.90 CHF).

In the literature, nonunions after ulna-shortening osteotomy occur in 0,[3,4] 7,[5] 10,[6] and 12.7%.[7] According to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) technique, callous should not be present in primary bone healing. Callous may reflect some motion at the fracture site. However, primary bone healing is a mechanism of fracture healing after watertight reduction, due to absolute congruity of both bone surfaces at the fracture site and absolute mechanical stability. In our opinion, this is almost never the case after an osteotomy. Then, there are bone debris from well cuttings and changes of vascularity due to heat from the saw blade, all leading to some periosteal phenomena presenting as callous.

Nonunion rates seem to be influenced by the size/rigidity of the implant,[8,9] smoking,[10] possibly by the site and orientation of osteotomy,[11–13] the size/temperature of the saw blade,[14] and others. Union rates have been higher when using more rigid implants. The 3.5-mm DC plates showed better healing than 2.7-mm plates.[8,9] In contrast, Koeppel et al[6] had comparable results using 2.7-mm DCP and 3.5-mm DCP. The length of a plate for internal fixation did not show a correlation to healing time according to Wehbé and Cautilli.[7]

Time to bony union was observed at a median of 10 weeks (range, 6–33 weeks) using a locking plate according to Schmidle et al.[15] Force in compression using a perpendicular clamp showed significantly better results than using a traditional compression screw technique.[16]

Smoking was proven as having a negative effect on bony union in ulnar shortening osteotomy, with a nonunion rate of 30% compared with nonsmokers. Chen et al found a mean union rate of 4.1 months in nonsmokers and 7.1 months in smokers.[10] Controversy exists whether oblique osteotomies heal faster than transverse ones.

Lautenbach et al[12] performed transverse osteotomies using a compression plate in 92 patients; 91 patients showed consolidation 6 months postoperatively, comparable to results when using oblique osteotomies. In contrast, Rayhack et al[13] found shorter healing time using an oblique cut at 11 weeks on average compared with 21 weeks using a transverse cut. Koeppel et al[6] had significantly shorter healing time at 4.6 months for an oblique osteotomy compared with 6.5 months for a transverse osteotomy. According to Fricker et al,[5] an advantage of performing an oblique osteotomy over a transverse one could not be detected, as one nonunion was present in each group. Rodriguez and Eglseder had no nonunion using an oblique osteotomy in 16 patients.[18]

In our study, oblique osteotomies tended to heal faster than transverse ones, without showing statistical significance. Definitely, the osteotomy-gap of a transverse cut is more probable to project in any X-ray beam than an oblique one, which might be an unavoidable confounder in answering this question.

It has also been hypothesized that healing might be faster and may be more reliable in metaphyseal than in diaphyseal osteotomies.[11] Nunez et al[19] used a metaphyseal ulnar shortening osteotomy in six patients and documented no nonunion.

In terms of implant removal, our rate was similar to the literature. A total of 4 implant removals were performed in 38 patients using the Trimed compression system (Trimed, Valencia, CA)[20]; in Pomerance's[21] series of 40 patients, 14 implants (12 Rayhack and two 3.5-mm Synthes dynamic compression plates) were removed because of persistent tenderness and discomfort over the plate site.[21] Wehbé and Cautilli[7] removed 91% of the plates at an average of 16 months after ulna-shortening osteotomy, having one fracture through the osteotomy site after a patient fell on his arm.

Factors determining the outcome after ulna-shortening osteotomy were longer duration of symptoms preoperatively and workers' compensation.[22]

Reported other less frequent complications were overcorrection resulting in disorders of the DRUJ,[17] osteoarthritic changes,[23] numbness/paresthesia over the dorsum of the wrist innervated by the dorsal sensory cutaneous branch of ulnar nerve,[24] superficial infection,[25] fractures through the osteotomy site after early plate removal,[7,21,23] and CRPS.[23] The latter was the second most frequent complication in our study. Frequency of postoperative complications may decrease with the learning curve of an orthopedic surgeon.

In conclusion, ulna-shortening osteotomy with either method, even with a considerably shorter plate, remains a technically safe treatment with a low complication rate. However, discomfort and tenderness on the plate site remains a problem often leading to plate removal and is not relevantly reduced with the use of the newer smaller sized and tapered implant. Only the more rapid healing of the osteotomy may outweigh the increased expenses related to the new implant.

Conflict of Interest
None.

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